A new Species of *Nitella* (Characeae) belonging to the Pluricellulate Species Group in Australia*

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A new species of *Nitella*, *Nitella woodii*, belonging to the pluricellulate species group in Australia, is described from the Nepean River, near Camden, New South Wales. The new species appears to be related to *Nitella cristata* and to *Nitella hookeri*, species endemic to the Australasian region.

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INTRODUCTION

During the course of systematic observations of charophytes in the Nepean River near Camden, New South Wales through the year 1968, a robust form of *Nitella* was found which is described here as a new species, *Nitella woodii*. The first specimen, taken in March while dredging for *Chara australis* in a deep pool near the highway bridge north of Camden, was a sterile fragment of a large plant resembling *Nitella flexilis*. In April, studies were concentrated on abundant charophyte beds in the more accessible shallow pools above and below the highway bridge of the airport road west of Camden. A single bed of the new species was apparently restricted to the shaded cooler depths of a pool directly under the bridge. This is the type locality. While the plants in this bed remained sterile and without new growth for several months, all other nearby species, grew and fruited abundantly in beds scattered up and down the river. These included: *Chara australis*, *Nitella sonderi*, *Nitella penicillata*, *Nitella tasmanica*, *Nitella imahorii* and *Nitella cristata*, among dioecious species and *Chara gymnopitys*, *Nitella imperialis* and *Nitella horikawi*, among the monoecious forms.

Meanwhile, in the new species, peculiar vegetative, bud-like growths appeared and were studied from April until August. The growths showed possible dormancy and vegetative reproductive traits suggesting the designation of winter buds or turions. In early spring (late August), a burst of bright green new growth rooted in the bottom mud replaced the darkened, decaying older plants. New turions appeared on the new shoots and fruiting of male and female gametangia was abundant on separated plants from October into November. The late winter early spring appearance of this species suggests that it is markedly seasonal.

The bed of the Nepean River presents generally favourable substrate conditions for the growth of charophytes. Coming from a sandstone region, the river winds in the Camden area in a shallow sandy trough over sandbars mixed with varying degrees of organic muck. Periodically flooded, scoured and reshaped by water currents, the sandy bottom presents a dynamic substrate which charophytes are well able to exploit quickly. In 1968, conditions were optimal for the growth of charophytes. The recently-scoured river bed presented broad expanses of clean, sandy bottom. There was a good supply of

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clean water in a shallow steady flow over rather broad shallow sandbars secure from competition from aquatic angiosperms along the shore. This favourable state continued through the following autumn, winter and into the spring when conditions slowly deteriorated partly as a result of encroaching sedges, silt and epiphytes, but mostly the result of the steadily lowering water level which left stretches of the river semistagnant and eventually in the grip of a drought, but not before the charophytes had produced an abundant crop of spores. In 1976 and in 1980, the first author revisited the site to find it under drought conditions. No collections could be made at either time.

Observations

Collections: Deep shaded pool, soft muddy bottom, under bridge, airport road, Nepean River, west of Camden, New South Wales.
A. T. Hotchkiss 68-3-13-2; 68-3-29-1 (observed in April); 68-6-29-2 (observed July, August); 68-10-5-1; 68-10-19-1; 68-11-3-1 (HOLOTYPE). Specimen, currently in University of Louisville Herbarium, will be transferred to the University of Sydney for disposition. Drawings made by K. Imahori from 68-10-19-1. Figs 1-13.

Diagnosis: *Nitella woodii A. T. Hotchkiss et K. Imahori.* Figs 1-13 *Nitella woodii* sp. nov. A. T. Hotchkiss et K. Imahori.

Planta dioecia, 30-100cm alta, viridis ad brunnea, gymnocarpa. Caulis robustus, 600-1250μ crassus; internodiis quam ramuli 2-plo longiora vel aequilonga. Verticilli steriles majores, ramulis 6, 2-3-tim furcatis, 8-11cm longi; radiis primarii totius longitudinis ramulorum 1/3-2/5, 2.5-4cm longi; radii secundarii 2-4, saepe cum ramulis accessoribus; radiis tertii 2-3; quaterni 2-3, abbreviati. Dactyli 2-3, (1-) 2-4 cellulati, inaequilongi; cellula ultima 55-100μ longa, ad basin 25-40μ lata.

Rami fertiles spiciformes ex apice vel axillari ramulorum secundari. Verticilli feminis quam masculi minus congesti vel similes; ramuli 6, 2-3 (-4) furcatis, 2-5.5cm longi; radii primarii totius longitudinis ramulorum 1/2-3/5; secundarii 3-4; tertii 3-4; quaterni 2-3, quorum 1 saepe in radiis quintis furcati. Dactyli 2-4, 2-3 cellulati; cellula ultima mucronata.

Gametangia ad nodos omnes exceptis primariis, solitaria. Antheridia 450μ longa et 420μ diametro. Oogonia brevi-stipitata, 675μ longa, 515μ lata; cellulae spirales 7-8; coronula parva, 35μ alta, cellula superiore quam inferiori 2-3 tim longiore, ad basin 50-55μ lata. Oospora fulva ad purpureo-brunnea, 515μ longa et 325μ lata; fossa 80μ lata; striis 5, paulum prominentibus. Membrana externa moniliformae; medius reticulata, trans *ca* 32 maculae; interior plane levis.

Plant Description: *Plants* large, usually about 33cm but up to 1m tall; new growth bright green colour, contrasting with older portions darker to brownish green to black; flexible and resembling *N. flexilis* in the field; *without mucus* (Figs 11-12). *Axes* moderately stout to stout in basal internodes, 600-1250μ in diameter, not encrusted; internodes about equalling upper branchlets in length to about twice the length of lower branchlets, 6-12cm long. *Branches* 1 large branch per node together with 1-2 later-formed and apparently secondary, smaller branches from its base; also usually an adventitious branch at the first furcation of a few or all sterile branchlets per whorl and in lower whorls of fertile branchlets. *Sterile branchlets* 6, 2-3 furcate, up to 8-11cm long, strongly ascending at the upper nodes to a little divergent below (Fig. 7). *Primary rays* about 0.3 to less than half the branchlet length, 2.5-4cm long. *Secondary rays* 2-4, one abaxial, slightly

broader and often monopodial or nearly so, some remain simple; and adventitious branch at first furcation often. *Tertiaries* 2-3, divergent but abaxial one less so and nearly or quite monopodial, some remain simple, as long dactyls. *Quaternaries* 2-3, usually as brachydactyls; one may be monopodial and longer, the other shorter and lateral, divergent. *Dactyls* 2-3, (1-)2-4-celled, variable in length, usually very long (2-3cm) as secondaries, or shorter (1cm) as tertiary rays, but brachydactylous (.2-.5mm long) as quaternaries (Fig. 5). A typical long dactyl with a long allantoid basal cell abruptly narrowing to a node, a shorter and narrower second cell also abruptly narrowing to a node, a short, conical, mucronate apical cell, or sometimes two cells in the mucro with the penultimate cell longer or shorter and either tapering smoothly into the end cell or the end cell abruptly mucronate. End cell 55-100μ long, 25-40μ broad at base, (1-celled dactyl: 80μ long, 25μ broad), often deciduous but leaving a truncate scar. *Longer dactyls* appear to result from a failure to fork at an upper node. *Brachydactyls* 2-3, (1-)2-3(-4)-celled, sometimes forming a mucronate 2-3-celled endpiece, smoothly or abruptly tapering down to an acute conical end cell, end cells similar to those on longer dactyls.

Fertile branchlets: (Figs 6, 8, 9), male and female gametangia on separate plants in terminal inflorescences consisting of whorls of 6 branchlets at first compacted into closer heads above, later elongating, spreading and widely spaced below (internodes 2.5-8cm) together with fertile axillary branches. The first fruiting appears at the base of an inflorescence with the development of a fertile axillary branch in a whorl of sterile or nearly sterile branchlets. Later there may be a second, smaller branch. A fertile adventitious branch may appear at the first furcation of the otherwise sterile branchlets in the basal whorl(s). Upwards in the inflorescence second and third branchlet whorls become progressively more fertile, shorter and accompanied by conspicuous fertile axillary branches. These are followed by several (3-4) whorls of completely fertile branchlets which may or may not terminate the stem. It appears in some cases that the growth of the stem axis continues with the production of further whorls of sterile branchlets above the fertile head.

Female inflorescence: lower branchlet whorls 6, 2-3-furcate, from 3-5.5cm long, primary rays 2-2.5cm long, mostly sterile but with fertile axillary branches and occasional adventitious branches at the first branchlet furcation; *upper branchlet whorls* 6, 2-3(-4)-furcate, form 2-2.5cm long; *primary rays* 1-1.5cm long; secondaries 3-4, one secondary ray usually broader, less divergent to monopodial; tertiaries 3-4, one may be central; quaternaries 2-3, one may be central and longer; quinaries 2-3, 2-3-celled, tiny, one ray may be longer. Dactyls 2-4, 2-3-celled, 0.3-4mm long in expanded mature branchlets, end cell short conical, mucronate, 50-120μ long, 25-35μ broad, or a 2-celled terminal mucro, occasionally deciduous.

Oogonia: (Fig. 2), short-stalked, solitary; 675μ (excl. coronula) long, 515μ broad; convolutions 7-8; *coronula* 35μ high, 50-55μ broad at base, upper cells overarching, 2-3 times longer than lower.

Oospores: (Fig. 1), dark, chestnut brown, 515μ long, 325μ broad; striae of 5 prominent and flanged ridges; fossa 80μ across; *membranes*: (Figs 3-4), outer, densely granulate to vermiferous; middle, finely reticulate about 32 meshes across; inner, smooth and clear.

Male inflorescence: lower branchlet whorls 6, 2-3-furcate, about 3-5cm long, similar to the female in arrangement, composition, and fertility but somewhat more spreading to reflexed, somewhat protandrous. *Primaries* about half the branchlet length, *secondaries* 3-4, *tertiaries* 2-4, *quaternaries* 2-3 where present, *quinaries* 2-3, 2-celled dactyls here present. *Dactyls:* 2-3, (1-)2-3-celled, up to 1.5cm long, or brachydactylous and (1-)2-3 very short cells in length. *Upper branchlet whorls* 6, 2-3(-4)-furcate, closer, shorter and more fertile than the branchlets below as in the female.

Antheridia: solitary at 2nd, 3rd and 4th furcations, absent at the first branchlet node, sometimes terminal at end of tertiary ray or 8 accompanied by minute quaternary dactyls; 450μ long, 420μ broad, 8-scutate.

Chromosomes: A chromosome number of n = 9 was established for *Nitella woodii* (A. and D. Hotchkiss) unpublished.

Turions: Muenscher (1944) calls a turion 'a hardened abbreviated axis or winter bud as in *Potamogeton*'. The use of the term 'turion' herein comes from a combination of suggested morphological and physiological similarity.

Winterbud-like structures or turions were observed from March to July on sterile overwintering plants in the Nepean River (Figs 10, 11, 13). The turions consisted of greatly swollen, starch-filled, food-storage cells. Turions in a main stem axis might include a single condensed whorl of primary rays, or primaries, secondaries and sometimes tertiaries as well, or two successive branchlet whorls including the connecting internodal cell. Often, a short axillary branch including the stem axis and one of two whorls of branchlets forms an axillary turion. The swollen ray cells form long narrow cylinders gradually tapered at the base, but abruptly tapered at the apex, and all become quite rigid.

Turions were brought into the laboratory and cultured in pans of water under lights in a constant temperature room. Germination was first observed in June after 4 to 6 weeks of cultivation. New growth from the turions produced normal stems and branchlets.

Occasionally in sterile branchlet whorls, more rarely in fertile whorls, new turions appear in the upper shoots with the new growth of early spring (August) and production of turions continues through the fruiting season (October-November). At this time it was seen that young turions may be fertile on normal nodes at a few furcations above the swollen turion rays. An attempt to germinate new turions was unsuccessful through December when the experiment was terminated.

Turion cells appear to be longer-lived and more resistant to adverse conditions than are the ordinary vegetative cells in both culture and in the field where they often become detached as a group and survive when other nearby cells are dead. It is likely that detached turions can serve as propagules and disseminules for the species. It seems possible that young turions possess some degree of dormancy which may assist in this role.

Turions such as these are apparently a useful taxonomic tool for delimiting *Nitella woodii* from many charophytes. They are probably not restricted to this species. For example, the second author found 'turions' in Japanese specimens of *Nitella annularis*. In addition, Wood and Imahori (1965) provided illustrations of *Nitella tumida* and *Chara submollusca*, which strongly suggest the presence of turions in the enlarged, inflated primary rays in certain whorls of branchlets.

Relationships

The establishment of this member of the genus *Nitella* as a new species was the result of a series of studies and observations.

(1) This large, robust species, complete with its unusual turions, was unique among all previously-studied forms.

(2) The differences in morphology coupled with its seasonal maturation in late winter, early spring, distinguished it from other charophytes in the Nepean River area.

(3) In its strong tendency to monopodial branchlet axis rays, the new species might be considered close to the *Nitella cristata* complex, (Wood and Imahori, 1965). It is

easily separated from *N. cristata* by additional morphological characteristics and by its difference, locally, in maturation time.

(4) As in much of the genus *Nitella*, the relationships of this species are most clearly indicated by the nature and number of cells in the dactyls. Its 1-4-celled dactyls place the species in the pluricellulate series of the Arthrodactylae. A combination of morphological characters narrows it down within the confines of Wood's key (1965) to the Section Incertae which contains *Nitella hookeri*, tentatively assigned as a form of the subgenus *Nitella* (which also includes *Nitella flexilis*) and *Nitella tasmanica*, in the subgenus *Hyella*.

The species resembles dioecious *N. tasmanica*, somewhat, but in general habit and in the form of its dactyls, it is closer to the monoecious *N. hookeri*. The two may be separated by *N. hookeri*'s geminate oogonia and coarsely reticulated oospore membrane. A chromosome number of n = 18 (A. and D. Hotchkiss, unpublished) was established for the monoecious *N. hookeri* (sensu *N. tricellularis*, fide R. D. Wood, collected by Wood in New Zealand) in 1961, whereas the dioecious *Nitella woodii* has a chromosome number of n = 9.

It would appear that the morphology of the species, its dioecious condition and its chromosome number provide sufficient distinctions to establish *Nitella woodii* as a separate species.

The new species has been named *Nitella woodii* in honour of the late Professor R. D. Wood, a leading student of the Charophyta.

ACKNOWLEDGEMENTS

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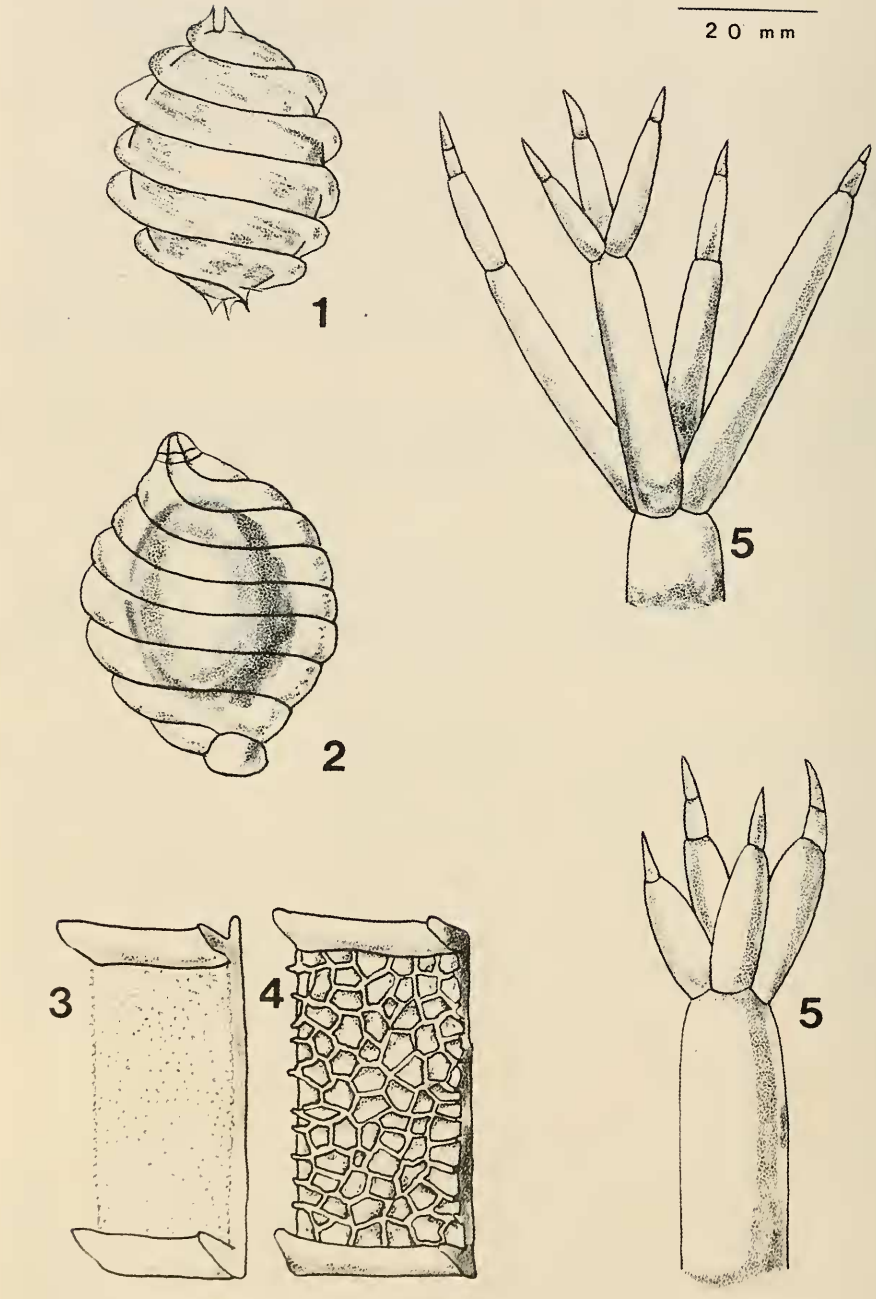


Figs 1-5. 1, Oospore, x90: 2, Oogonium, x75. 3, Spore Membrane, lower focus, x600. 4, Spore Membrane, higher focus, x600. 5, Dactyls at apices of sterile branchlets, x75.

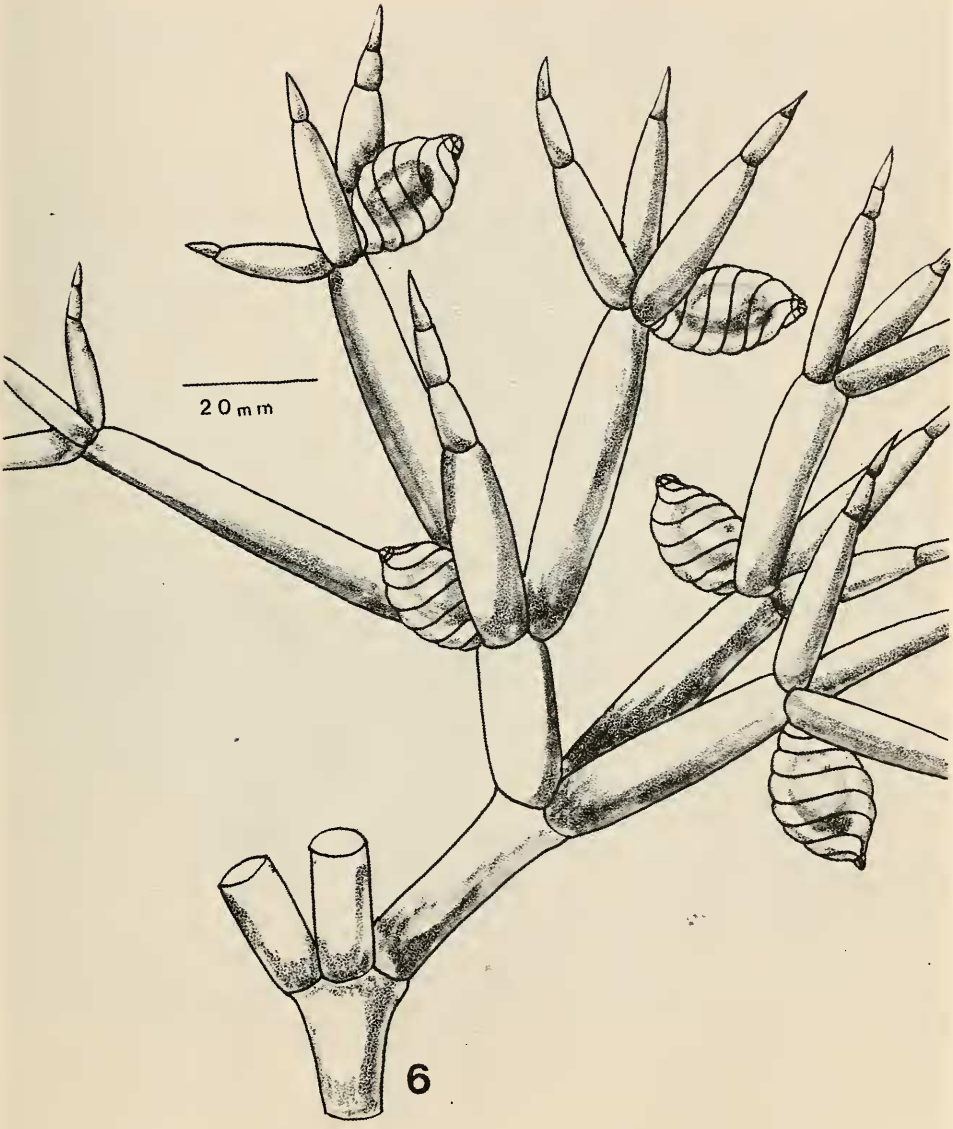
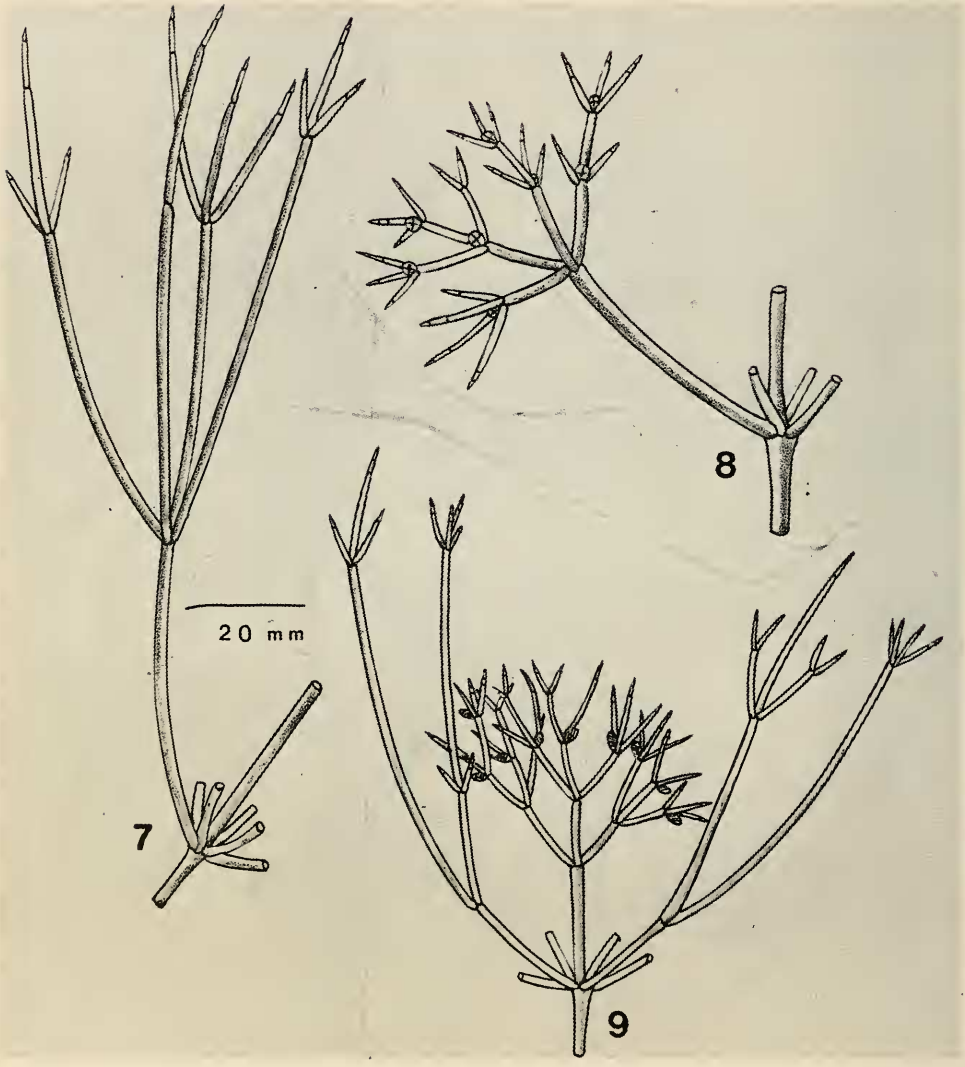


Fig. 6. Fertile female branchlet, x30.



Figs 7-9. 7, Sterile branchlet, x4.5. 8, Male branchlet, x9. 9, Female branchlet, x6.

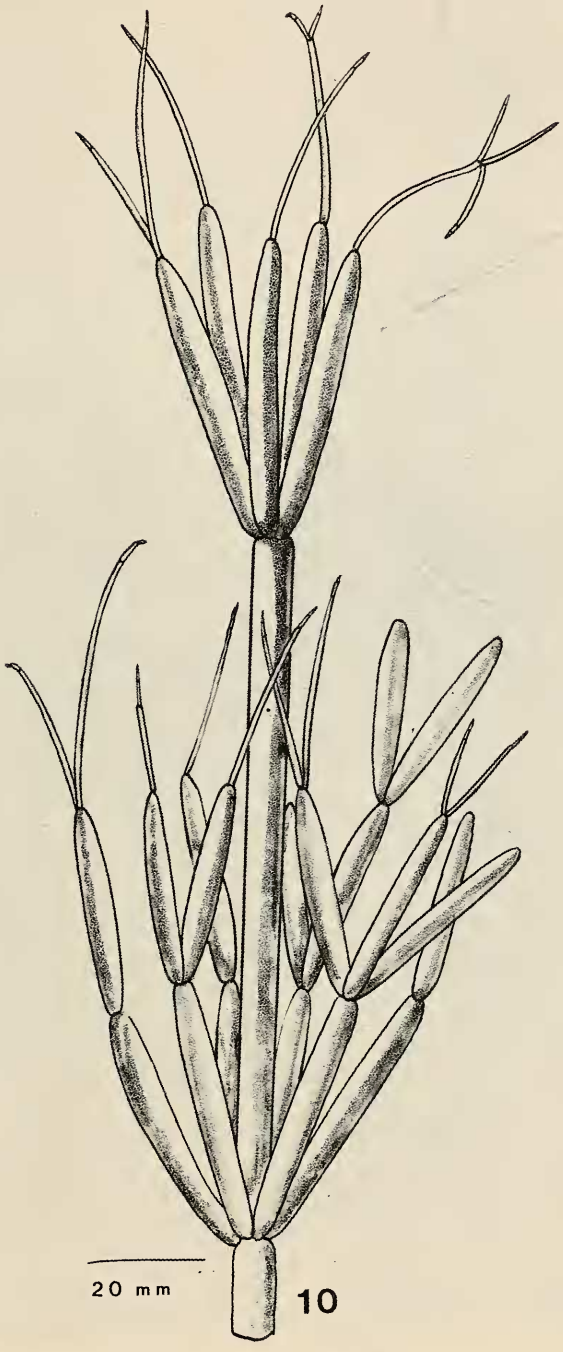
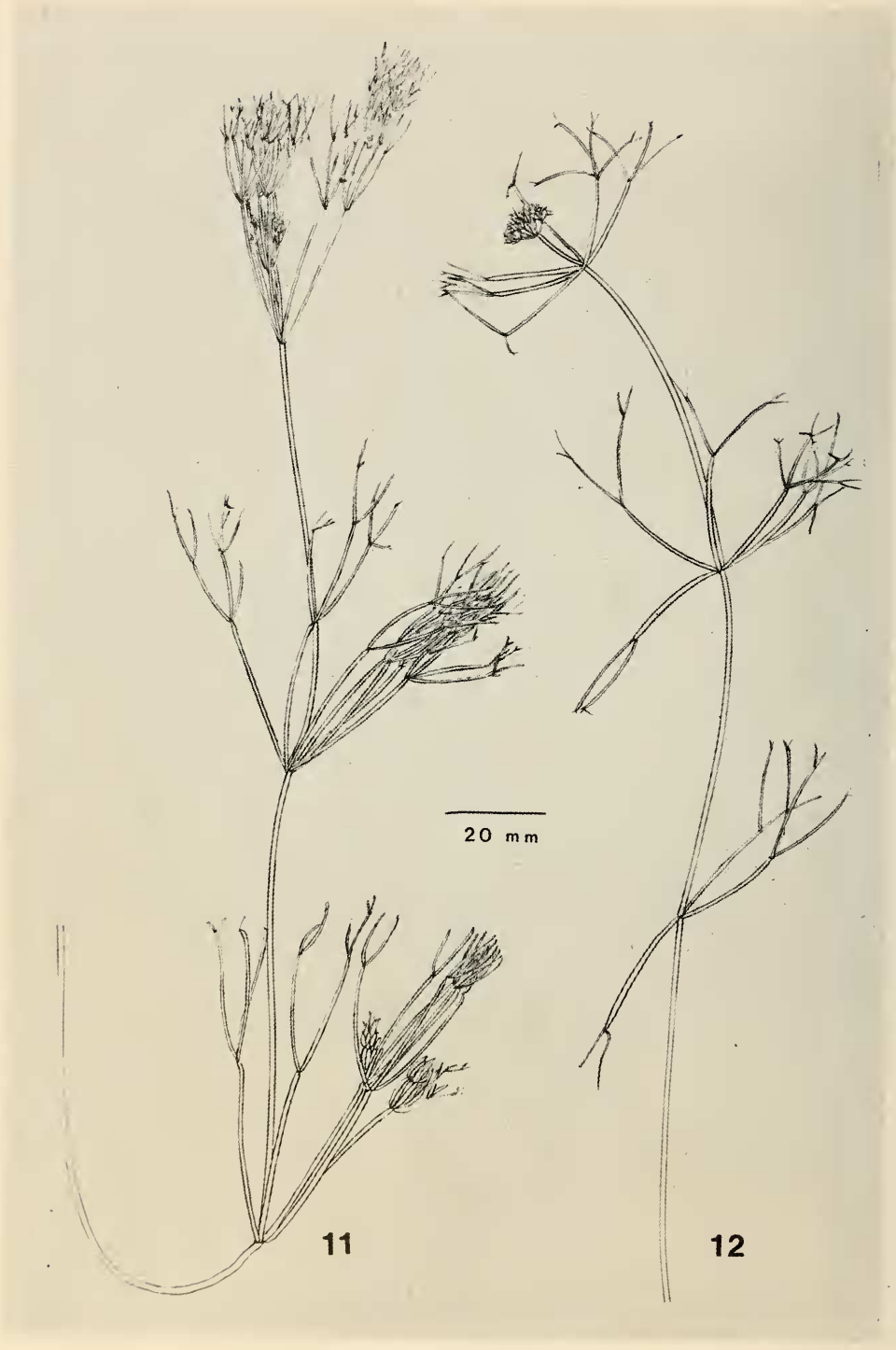


Fig. 10. Turions in two whorls of branchlets, x7.5.



Figs 11-12. 11, Habit of female plant, turions in lower branchlet whorl, x3/2. 12, Habit of male plant, x3/2.

Fig. 13. Turions stained with iodine. Slide prepared and photographed at the University of Sydney.